Variation of multiplicity of intermediate mass fragments and differential charge distributions with Z_{bound} in projectile fragmentation reactions.

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Projectile fragmentation reactions at intermediate energies characterized by the emission of several intermediate mass fragments ($3 \leq Z \leq 20$) is a natural continuation of fission towards complete vaporization. In this work using a projectile fragmentation model, we study the average number of intermediate mass fragment production as a function of Z_{bound}(=sum of charges of all projectile fragments with $Z > 1$) and charge distributions at different Z_{bound} intervals for Sn^{107} and Sn^{124} on natural tin(Sn^{119}) reactions at 600 Mev per nucleon energy.
The model for projectile fragmentation consists of three stages: (i) abrasion, (ii) multifragmentation and (iii) evaporation. In heavy ion collision, if the beam energy is high enough then at a particular impact parameter three different regions are formed: (i)projectile like fragment (PLF) or projectile spectator moving in the lab with roughly the velocity of the beam, (ii) participant which suffer direct violent collisions and (iii) target like fragment (TLF) or target spectator which have low velocities in the lab. Experimentally projectile like fragments (PLF) which move roughly in the beam direction are easier to collect and analyze. From the abrasion stage calculations the charge and mass of the PLF is obtained at different impact parameters. Experimentally neither impact parameter nor average charge (Z_s) of the abraded projectile Z_s can be measured directly, indirect determination of impact parameter is done by measuring Z_{bound}. Fig.-1 shows the variation of average charge (Z_s) and Z_{bound} of the abraded projectile with impact parameter for Sn^{107} on Sn^{119} reaction.

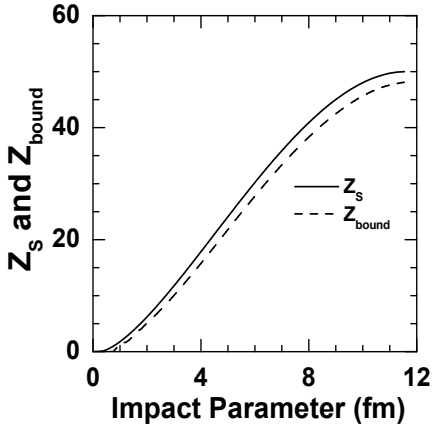

FIG. 1: Theoretical variation of average charge (solid line) and Z_{bound} (dashed line) with impact parameter for Sn^{107} on Sn^{119} reaction.

The multifragmentation stage calculation of each PLF created after abrasion at different impact parameters is done separately by the Canonical Thermodynamical Model (CTM) [1] .The canonical thermodynamical model assumes that due to density fluctuations each nuclear system (here projectile like fragments produced after abrasion stage) breaks up and reaches to an expanded freeze-out configuration at a particular temperature. This temperature profile is obtained by looking at many pieces of data from many nuclear collisions. For projectile fragmentation reactions we consider that the temperature of the fragmenting systems decreases from 7.5

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MeV (at most central collision) to 3.0 MeV (at most peripheral collision).
After multifragmentation stage excited fragments are produced at different temperatures depending upon the impact parameters. Finally, the decay of excited fragments are calculated by evaporation model [2] based on Weisskopf's formalism.
The variation of the average number of intermediate mass fragments with Z_{bound} is shown in Fig.2. At small impact parameters, the size of the projectile spectator (also Z_{bound}) is small and the temperature of the dissociating system is very high. Therefore the PLF will break into fragments of small charges (mainly $Z = 1, 2$). Therefore the IMF production is less. But at mid-central collisions PLF's are larger in size and the temperature is smaller compared to the previous case, therefore larger number of IMF's are produced. With further increase of impact parameter, though the PLF size (also Z_{bound}) increases, the temperature is low, hence breaking of dissociating system is very less(large fragment remains) and therefore IMF production is less.

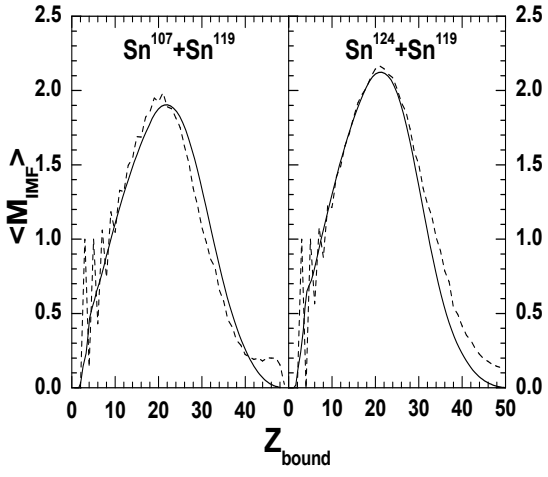

FIG. 2: Theoretical mean multiplicity of intermediate-mass fragments (solid lines) M_{IMF}, as a function of Z_{bound} for ^{107}Sn on ^{119}Sn (left panel) and ^{124}Sn on ^{119}Sn (right panel) compared with experimental data [3] (dashed lines).

The differential charge distributions for different intervals of Z_{bound}/Z_0 are shown in Fig.3. For the sake of clarity the distributions are normalized with different multiplicative factors. At peripheral collisions (i.e. $0.8 \leq Z_{bound}/Z_0 \leq 1.0$) due to small temperature of PLF, it breaks into one large fragment and small number of light fragments, hence the charge distribution shows U type nature. But with the decrease of impact parameter the temperature increases, the PLF breaks into larger number of fragments and the charge distributions become steeper.

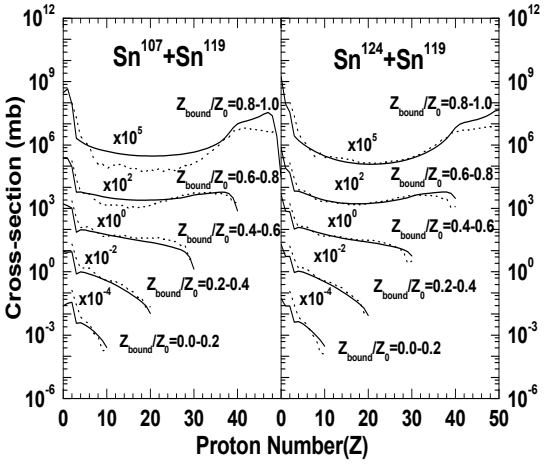

FIG. 3: Theoretical differential charge distribution (solid lines) for ^{107}Sn on ^{119}Sn (left panel) and ^{124}Sn on ^{119}Sn reaction (right panel) compared with experimental data (dotted lines).

Therefore we can conclude that the variation of average number of intermediate mass fragments $< M_{IMF} >$ with Z_{bound} and charge distributions at different Z_{bound} intervals is nicely reproduced and explained by the projectile fragmentation model.

References

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